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## Risk Factors for Lower Extremity Tendinopathies in Military Personnel

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## Abstract

**Background:** Lower extremity tendinopathies remain an important injury among military personnel, but potentially modifiable risk factors for these outcomes have not been prospectively examined.

**Purpose:** To prospectively identify risk factors for the development of lower extremity tendinopathy in U.S. military personnel.

**Methods:** We utilized baseline data from the Millennium Cohort Study, a long-term observational cohort of military personnel. Service members were enrolled in the Cohort in 2001, 2004, and 2007. We followed 80,106 active-duty subjects for the development of patellar tendonitis, Achilles tendonitis, and plantar fasciitis over 1 year as assessed by review of Department of Defense medical records. Regression analyses were used to estimate significant associations between tendinopathy outcomes and demographic, behavioral, and occupational characteristics.

**Results:** Using medical records 450 cases of Achilles tendinitis, 584 cases of patellar tendinitis, and 1228 cases plantar fasciitis were identified. Recent deployment was associated with an increased risk for developing plantar fasciitis (adjusted odds ratio [AOR] = 1.27, 95% confidence interval [CI] = 1.04, 1.56). Moderate weekly alcohol consumption was marginally associated with an increased risk for Achilles tendinitis (AOR = 1.35, 95% CI = 1.00, 1.76). Overweight or obese individuals were more likely to develop both Achilles tendinitis and plantar fasciitis. Specific occupations, including health care workers, were at significantly higher risk for developing plantar fasciitis.

**Conclusions:** Lower extremity tendinopathies are common among military service members and this study identified several modifiable risk factors for their occurrence.

These potential risk factors could serve as the focus for future preventive and intervention studies.

## Introduction

Tendinopathies of the lower extremity can have a significant impact on activity levels. Reports have shown that Achilles, patellar, and quadriceps tendon tears as well as plantar fasciitis are common in U.S. military populations.<sup>1,2</sup> Although studies to date have demonstrated a wide range of tendon injuries affecting a sizeable proportion of personnel in the U.S. military, they were not able to evaluate and quantify occupational or behavioral risk factors. While uncertainty remains about the cellular mechanisms of tendinopathy, important behavioral risk factors such as tobacco consumption<sup>3</sup> and occupational exposures<sup>4</sup> are gaining more interest. Underlying the disproportionate incidence of tendinopathy in military populations, may be the high priority placed on strenuous and continuous physical training, as well as the demands of deployment.

The military is an ideal population to study tendonopathies given its access to both primary care providers as well as specialty care. A greater understanding of modifiable risk factors may lead to the design and testing of intervention strategies. With prevention as the ultimate goal, the impact could significantly enhance military operational readiness, as well as have implications for the prevention of tendon injuries across other occupational groups and the general public.

The Millennium Cohort Study prospectively collects information on deployment exposures, as well as important demographic and behavioral risk factor information. The main objective of our study was to identify and evaluate any influence of both non-modifiable and modifiable risk factors, including military deployment in support of the

operations in Iraq and Afghanistan, on the occurrence of Achilles tendinitis, patellar tendinitis, and plantar fasciitis.

## Methods

### Study Population

Data for these analyses included participants from three enrollment panels of the Millennium Cohort Study.<sup>5,6</sup> The goal of this large prospective military cohort study is to assess any long-term health outcomes of military service, as well as to evaluate potential impacts of deployment and other military-related experiences. Subjects were enrolled during three cycles (Panels 1, 2 and 3) between 2001 and 2008. The first panel was drawn from a population-based stratified random sample of all U.S. military personnel serving on rosters as of October 2000, with oversampling for those who had been previously deployed, Reserve and National Guard, and women. Panels 2 and 3 employed the same general selection strategy, but differed in criteria for oversampling: prior deployment was not a selection criterion, but the group was restricted by duration of service (1–2 years = Panel 2; 1–3 years = Panel 3), and Marine Corps members and women were over-sampled. A total of 77,047 participants were enrolled in Panel 1 (2001–2003), 31,110 participants enrolled in Panel 2 (2004–2006), and 43,440 participants enrolled in Panel 3 (2007–2008). For our analyses, only active-duty participants who had not separated from military service by the end of the study time frame ( $n=80,106$ ) were evaluated since obtaining study outcomes required Department of Defense electronic medical records. This study was approved by the Naval Health

Research Center Institutional Review Board (protocol NHRC.2000.0007), and informed consent was obtained from all study subjects.

### **Data Sources**

Demographic, military, health, lifestyle, and behavioral information, including body mass index (BMI), tobacco, and alcohol consumption, were collected using the Millennium Cohort questionnaire. Electronic military personnel records were provided by the Defense Manpower Data Center (DMDC) including date of birth, sex, race/ethnicity, marital status, education, military occupation, paygrade, service branch, component and deployment dates. .

Electronic medical records data were obtained from the Military Health Service Data Repository (MDR). The MDR provided all inpatient and outpatient hospitalization records from TRICARE-approved DoD military treatment facilities as well as inpatient and outpatient encounters at civilian medical facilities if there was a fee for services. MDR data were available for Service members who are eligible to receive benefits, including, but not limited to, activated Reservist and active-duty personnel.

### **Outcomes of Interest**

Our study examined three lower extremity tendinopathies: Achilles tendinitis, patellar tendinitis and plantar fasciitis, determined by the presence of their respective ICD-9 codes, 726.71/727.67, 726.64/727.66, and 728.71. These ICD-9 codes represent tendinopathies which may have been caused by acute injury or the result of chronic

pathology; alternative codes for acute injuries, such as sprains and strains (840-848 series), were not considered for this study. Each tendinopathy was analyzed as a separate outcome.

## Exposure Variables

Demographic and military covariates for analyses included birth year, sex, race/ethnicity, Service branch, component, pay grade, military occupation, and deployment up to 6 months prior to baseline (see Table 1). Health and behavioral covariates obtained from the Millennium Cohort questionnaires, included tobacco use, alcohol consumption, BMI, and depression symptoms. Tobacco use was based on participant responses to a set of survey questions asking if they had ever smoked at least 100 cigarettes in their lifetime and if they had ever successfully quit smoking. Weekly alcohol consumption was calculated separately for men and women. For men, weekly alcohol consumption was categorized as None (0 drinks), Light (1–6 drinks), Moderate (7–13 drinks), or Heavy (>13 drinks), and for women as None (0), Light (1–3), Moderate (4–6), Heavy (>6 drinks).<sup>7</sup> BMI was categorized based on Centers for Disease Control and Prevention guidelines [underweight (<18.5 kg/m<sup>2</sup>), normal weight (18.5–24.9), overweight (25.0–29.9), and obese ( $\geq 30$ )]. Depression symptoms were assessed using the Patient Health Questionnaire-9.<sup>8-11</sup> Prior physical trauma or injury was assessed using electronic medical records to obtain ICD-9 codes for fractures and several lower extremity tendinopathies (Achilles tendinitis, patellar tendinitis, and plantar fasciitis) that occurred prior to baseline. Finally, validated scoring algorithms were used to assess the physical component summary scores for the Medical Outcomes Study Short Form 36-Item Survey

for Veterans (SF-36V).<sup>12-14</sup> All covariates were determined *a priori*, to include known risk factors, as well as the behavioral characteristics of interest.

## Statistical Analysis

Descriptive and univariate analyses were used to investigate population characteristics. Unadjusted associations of tendinopathy outcomes with modifiable and non-modifiable risk factors were determined using Chi-square analysis. This study was prospective in design, as all covariate data were measured at baseline prior to reporting of any of the outcomes in the electronic medical records. True incidence of chronic pathology was understood to be difficult to assess using medical records, but recording of previously unrecognized diagnoses defined the study outcomes. Electronic medical records were queried for any tendinopathy up to 1 year following baseline assessment. Multivariable logistic regression models were used to determine the adjusted odds of tendinopathy injury while controlling for relevant baseline covariates. Adjusted odds ratio (AOR) and 95% confidence interval (CI) are presented. Regression diagnostics were used to assess collinearity between all covariates using a variance inflation factor cut-off of 4 or greater to indicate potential collinearity. Over 30 percent of those who developed a tendinopathy following baseline also had a tendinopathy prior to baseline in the medical records. This led us to conduct a sensitivity analysis to examine newly-reported tendinopathies following baseline among those without a prior tendinopathy. Additionally, since each tendinopathy could occur within one year of baseline, secondary analyses were also performed to include time from baseline to date of the tendinopathy medical visit, using Cox proportional hazards - time to event analyses. Data management and statistical

analyses were performed using SAS statistical software, version 9.2 (SAS Institute, Inc., Cary, NC).

## Results

Characteristics of active-duty Millennium Cohort participants by tendinopathy type are presented in Table 1. Out of 80,106 participants, 450 Service members were diagnosed with Achilles tendinitis, 584 had patellar tendinitis, and 1228 had plantar fasciitis within 1 year of their baseline. Unadjusted associations are detailed in Table 1.

In adjusted analyses of lower extremity injuries (Table 2), overweight or obese individuals and moderate weekly alcohol drinkers had significantly increased risk for developing Achilles tendinitis. A near-linear pattern showed younger age was associated with lower risk for Achilles tendinitis. Army personnel had increased risk compared with all other services, although the odds ratio was not significant when comparing Army directly to Marine Corps. Other military-specific variables, including deployment, were not significantly associated with Achilles tendinitis. Those personnel with a prior tendinopathy or fracture were over 3 times more likely to develop Achilles tendinitis compared with those with no prior injury (AOR = 3.87, 95% CI = 3.16, 4.75) and those who scored in the highest 15% according to the SF-36V physical component summary score had decreased odds compared with the middle 70%.

Risk factors for patellar tendinitis varied somewhat from Achilles tendinitis (Table 2). A near- inverse linear relationship existed with younger age associated with higher odds for

patellar tendinitis. Those in the Army and other technical and allied specialists had increased odds for developing patellar tendinitis, while recent deployment was not significantly associated. Similar to Achilles tendinitis, those with a prior injury were almost 3 times more likely to develop patellar tendinitis.

Recent deployment was significantly associated with higher odds of having plantar fasciitis ( $AOR = 1.27$ , 95% CI = 1.04, 1.56). Current smokers had reduced odds, while overweight and obese individuals had increased odds of being diagnosed with plantar fasciitis. Service in the Army and several occupation categories, including electronic equipment repair, health care workers, function support and administration, and service and supply handlers, had increased odds for developing plantar fasciitis. Age and sex were both significant predictors: women had higher odds and younger military personnel had lower odds of plantar fasciitis diagnoses. Participants with a history of tendinopathy or fracture were over 4 times more likely to be diagnosed with plantar fasciitis compared with those with no injury history.

Results for the sensitivity analyses, where those with a prior injury were removed from the models, were consistent with the main models. Deployment was not significantly associated with the development of Achilles or patellar tendinitis, but was significant in the plantar fasciitis model ( $AOR: 1.30$ , 95% CI 1.02, 1.67). Results from the secondary, time to event, analyses were also consistent with the main models where deployment was significant only in the plantar fasciitis model ( $AOR: 1.25$ , 95% CI 1.03, 1.52). Similar

trends were noted with regards to age, BMI and alcohol use in both the sensitivity and secondary analyses.

## **Discussion**

Because of the high incidence of deployment-related injuries in theater,<sup>15</sup> this study investigated risk factors for three lower extremity tendinopathies among U.S. Service members deployed to recent military operations in Iraq and Afghanistan with the main objective to identify any modifiable factors not previously described in a military population. This study found that plantar fasciitis was significantly related to military deployment. Findings also identified elevated BMI as an important, potentially modifiable, risk factor for the development of plantar fasciitis and Achilles tendinitis. Moderate drinking was marginally associated with the development of Achilles tendinitis. Other risk factors that may help focus future research or intervention and prevention strategies for these outcomes include previous tendinopathy or fracture diagnosis, certain military occupations, and lower self-perceived physical health.

The Achilles tendon is the largest and strongest tendon in the human body and injury to this tendon, including rupture, is common in athletes.<sup>16</sup> Our finding of Achilles tendinitis in older adults in the military is consistent with the epidemiology of these disorders in other physically active populations. However, our finding of nearly equal incidence in men and women in the military differs from findings in the general population, where research has shown Achilles tendinopathies may occur more frequently in men,<sup>16, 17</sup> Although several small studies of active populations have demonstrated that women have

increased odds for tendon injury, our findings likely reflect the relative equivalence between men and women in the military performing activities that stress the Achilles tendon.<sup>18, 19</sup> We found a fairly strong and consistent relationship between high BMI and Achilles tendinitis in this military cohort as has been reported in other populations,<sup>17, 20</sup>. Finally, our finding of a relationship between heavier levels of alcohol consumption and Achilles tendinitis was unique to this lower extremity disorder, and it has not been described previously. Alcohol may be associated with risk-taking behaviors and over-use activities that may lead to injury. Additionally, alcohol may affect metabolic or inflammatory factors that are associated with Achilles tendinitis.<sup>21</sup> The magnitude of the odds ratio for these associations were modest (1.27–1.33) and not all statistically significant, however the trend for heavier alcohol use associated with Achilles disorders deserves further study.

The etiology of plantar fasciitis is not well understood and is probably multi-factorial.<sup>22</sup> Repetitive stress and trauma are suspected as underlying etiologies due to the higher occurrence of this condition in persons who are overweight, run in marathons, or spend a large amount time on their feet each day.<sup>23-25</sup> One would expect the tempo and stress of deployments to result in a higher risk for this outcome, as was confirmed in our analyses. In addition to this novel finding, we also observed several occupational classifications associated with a higher risk of plantar fasciitis. Although we were not able to determine specific daily occupational duties performed, certain military personnel required to be on their feet for long hours may have increased risk for developing plantar fasciitis. We also found a curiously lower risk in current smokers that could not be explained by the

tendency for smokers to be lighter, since our model was adjusted for overweight/obesity (Table 2). Our results showing a higher risk with overweight and obesity echo previous research, and the association with Army service probably reflects more time spent on their feet and repetitive-use injury in this branch of service.<sup>20</sup> Prior research in the military reported a higher risk of plantar fasciitis in women and members of the Army, consistent with our findings, but a higher risk in Marines as well, a finding not seen in our population.<sup>1</sup> Our results also raise a number of intriguing possibilities for further investigation to attempt to better understand and more clearly define the role of certain occupational classifications with regard to risk of plantar fasciitis.

Most prior studies have focused on non-modifiable risk factors such as demographics for the development of lower extremity tendinopathies.<sup>1,2</sup> Previous research has shown that age greater than 30 years, men, and black race were significant demographic risk factors for patella and Achilles tendon ruptures in a U.S. military population.<sup>2</sup> Those results were not replicated in the current study, where sex and race were not significant for patellar or Achilles tendinopathies and the youngest age group (born 1980 and later) had the highest risk for developing patellar tendinitis, while that same age group had the lowest risk for developing Achilles tendinitis and plantar fasciitis. Although not seen in the patellar tendinitis model, increasing age has consistently been cited as a risk factor for tendinopathy.<sup>26-28</sup> What is unclear is the role of sex and race, as these demographic determinations may also interact with activity levels as well as anatomic risk factors (e.g., ligamentous laxity, foot anatomy) that act as confounding factors. Other factors, such as

estrogen levels,<sup>18, 19</sup> in these demographic categories may also suggest a different genetic blueprint for tendon microanatomy or differed response to loading and/or injury.<sup>28</sup>

The current study has several important limitations that should be noted. We hypothesized that deployment would be associated with each of the injuries we examined, but we found this only to be true for plantar fasciitis. The lack of observed association may be due to the fact that the Millennium Cohort Study provides a large population level view of risk factors and there was limited exposure assessment in theater that would have allowed a more granular investigation. Our findings would surely vary among distinct subgroups of the deploying population who had higher burden of activities that would result in these injuries. Further, limited or non-existent visibility of injuries treated in the field would have resulted in missing injuries where individuals did not seek medical care after returning from deployment. Analyses were restricted to active-duty personnel because complete availability of medical record data is limited among Reserve and National Guard members and individuals who separate from the military. The use of medical record data to measure morbidity also restricted our analyses to injuries severe enough to warrant medical treatment and may not measure all morbidity. This investigation focused on the first injury event to occur in each lower limb tendinopathy category in the first year following baseline assessment, though most tendinopathies are chronic conditions and may be episodic in nature. In addition, since we were only able to identify occupational categories, but not actual tasks performed on the job, we were unable to draw meaningful conclusions regarding occupational risk factors for plantar fasciitis. Other important data that may affect the development of

lower extremity tendinopathies, including footwear and physical activity, were not available for inclusion in these models. Finally, results were not statistically adjusted for multiple comparisons, so some of the findings observed in this study may have been due to chance alone.

There were also several strengths of this study. First, this study examined modifiable risk factors associated with lower body tendinopathies which, to our knowledge have not been studied previously among a military population. Sub-analyses performed using participants without a prior tendinopathy were consistent with the main regression models as was time to event modeling, demonstrating that our methods were robust and valid. The population-based, prospective cohort design allowed for adjustment of several potential confounders measured at baseline, including prior tendinopathy or fracture diagnoses. Additionally, the large sample size provided robust power to investigate associations with lower body tendinopathies even among smaller subgroups of the population.

In conclusion, this study examined potential risk factors, including military deployment, related to the occurrence of three lower extremity tendinopathies and found plantar fasciitis significantly associated with deployment in support of the operations in Iraq and Afghanistan. Other potentially modifiable risk factors associated with lower extremity tendinopathy outcomes included overweight/obesity, alcohol consumption, and certain job types. To our knowledge, this is the first investigation of these outcomes that focuses on population level data. Other research is still needed that converges on subgroups of the

population with higher propensity for injury. This work may also help focus preventive efforts for tendinopathies in military and other working adult populations.

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## References

1. Scher DL, Belmont PJ, Jr., Bear R, Mountcastle SB, Orr JD, Owens BD. The Incidence of Plantar Fasciitis in the United States Military. *J Bone Joint Surg Am.* 2009 Dec;91(12):2867-72.
2. Owens B, Mountcastle S, White D. Racial Differences in Tendon Rupture Incidence. *Int J Sports Med.* 2007 Jul;28(7):617-20.
3. Kane SM, Dave A, Haque A, Langston K. The Incidence of Rotator Cuff Disease in Smoking and Non-Smoking Patients: A Cadaveric Study. *Orthopedics.* 2006 Apr;29(4):363-6.
4. Zakaria D. Rates of Carpal Tunnel Syndrome, Epicondylitis, and Rotator Cuff Claims in Ontario Workers During 1997. *Chronic Dis Can.* 2004 Spring;25(2):32-9.
5. Ryan MA, Smith TC, Smith B, Amoroso P, Boyko EJ, Gray GC, et al. Millennium Cohort: Enrollment Begins a 21-Year Contribution to Understanding the Impact of Military Service. *J Clin Epidemiol.* 2007 Feb;60(2):181-91.
6. Gray GC, Chesbrough KB, Ryan MA, Amoroso P, Boyko EJ, Gackstetter GD, et al. The Millennium Cohort Study: A 21-Year Prospective Cohort Study of 140,000 Military Personnel. *Mil Med.* 2002 Jun;167(6):483-8.
7. US Department of Agriculture and US Department of Health and Human Services. Dietary Guidelines for Americans 2010. Washington DC. Available at: <http://www.health.gov/dietaryguidelines/2010.asp>. Accessed April 6, 2011.
8. Spitzer RL, Kroenke K, Williams JB. Validation and Utility of a Self-Report Version of Prime-MD: The PHQ Primary Care Study. *Primary Care Evaluation of Mental Disorders. Patient Health Questionnaire. JAMA.* 1999 Nov 10;282(18):1737-44.

9. Kroenke K, Spitzer RL, Williams JB. The Phq-9: Validity of a Brief Depression Severity Measure. *J Gen Intern Med.* 2001 Sep;16(9):606-13.
10. Spitzer RL, Williams JB, Kroenke K, Hornyak R, McMurray J. Validity and Utility of the Prime-Md Patient Health Questionnaire in Assessment of 3000 Obstetric-Gynecologic Patients: The Prime-Md Patient Health Questionnaire Obstetrics-Gynecology Study. *Am J Obstet Gynecol.* 2000 Sep;183(3):759-69.
11. Fann JR, Bombardier CH, Dikmen S, Esselman P, Warms CA, Pelzer E, et al. Validity of the Patient Health Questionnaire-9 in Assessing Depression Following Traumatic Brain Injury. *J Head Trauma Rehabil.* 2005 Nov-Dec;20(6):501-11.
12. Kazis LE, Lee A, Spiro A, III, Rogers W, Ren XS, Miller DR, et al. Measurement Comparisons of the Medical Outcomes Study and Veterans Sf-36 Health Survey. *Health Care Financ Rev.* 2004 Summer;25(4):43-58.
13. McHorney CA, Ware JE, Jr., Lu JF, Sherbourne CD. The Mos 36-Item Short-Form Health Survey (Sf-36): Iii. Tests of Data Quality, Scaling Assumptions, and Reliability across Diverse Patient Groups. *Med Care.* 1994 Jan;32(1):40-66.
14. McHorney CA, Ware JE, Jr., Raczek AE. The Mos 36-Item Short-Form Health Survey (Sf-36): II. Psychometric and Clinical Tests of Validity in Measuring Physical and Mental Health Constructs. *Med Care.* 1993 Mar;31(3):247-63.
15. Smith TC, Corbeil TE, Ryan MA, Heller JM, Gray GC. In-Theater Hospitalizations of Us and Allied Personnel During the 1991 Gulf War. *Am J Epidemiol.* 2004 Jun 1;159(11):1064-76.
16. Jarvinen TA, Kannus P, Maffulli N, Khan KM. Achilles Tendon Disorders: Etiology and Epidemiology. *Foot Ankle Clin.* 2005 Jun;10(2):255-66.

17. Hess GW. Achilles Tendon Rupture: A Review of Etiology, Population, Anatomy, Risk Factors, and Injury Prevention. *Foot Ankle Spec.* 2010 Feb;3(1):29-32.
18. Knobloch K, Schreibmueller L, Meller R, Busch KH, Spies M, Vogt PM. Superior Achilles Tendon Microcirculation in Tendinopathy among Symptomatic Female Versus Male Patients. *The American journal of sports medicine.* 2008 Mar;36(3):509-14.
19. Wilber CA, Holland GJ, Madison RE, Loy SF. An Epidemiological Analysis of Overuse Injuries among Recreational Cyclists. *International journal of sports medicine [Research Support, Non-U.S. Gov't].* 1995 Apr;16(3):201-6.
20. Wearing SC, Hennig EM, Byrne NM, Steele JR, Hills AP. Musculoskeletal Disorders Associated with Obesity: A Biomechanical Perspective. *Obes Rev.* 2006 Aug;7(3):239-50.
21. Langberg H, Skovgaard D, Karamouzis M, Bulow J, Kjaer M. Metabolism and Inflammatory Mediators in the Peritendinous Space Measured by Microdialysis During Intermittent Isometric Exercise in Humans. *The Journal of physiology [Research Support, Non-U.S. Gov't].* 1999 Mar 15;515 ( Pt 3):919-27.
22. Buchbinder R. Clinical Practice. Plantar Fasciitis. *N Engl J Med.* 2004 May 20;350(21):2159-66.
23. Fredericson M, Misra AK. Epidemiology and Aetiology of Marathon Running Injuries. *Sports Med.* 2007;37(4-5):437-9.
24. Riddle DL, Pulisic M, Pidcoe P, Johnson RE. Risk Factors for Plantar Fasciitis: A Matched Case-Control Study. *J Bone Joint Surg Am.* 2003 May;85-A(5):872-7.
25. Sadat-Ali M. Plantar Fasciitis/Calcaneal Spur among Security Forces Personnel. *Mil Med.* 1998 Jan;163(1):56-7.

26. Paavola M, Kannus P, Jarvinen TA, Khan K, Jozsa L, Jarvinen M. Achilles Tendinopathy. *J Bone Joint Surg Am.* 2002 Nov;84-A(11):2062-76.
27. Sharma P, Maffulli N. Tendon Injury and Tendinopathy: Healing and Repair. *J Bone Joint Surg Am.* 2005 Jan;87(1):187-202.
28. Rees J, Maffulli N, Cook J. Management of Tendinopathy. *Am J Sports Med.* 2009 Feb 5.

**Table 1.** Baseline behavioral, demographic, and military characteristics of 80,106 active-duty personnel (2001–2008)

	No tendon injury <i>N</i> =77,902 %	Achilles tendinitis <i>N</i> =450 %	Patellar tendinitis <i>N</i> =584 %	Plantar fasciitis <i>N</i> =1228 %
<b>Baseline characteristics</b>				
Deployment <sup>*a</sup>				
No	89.66	91.33	89.73	90.88
Yes	10.34	8.67	10.27	9.12
Birth year				
Pre-1960	5.34	8.22*	3.42*	9.77*
1960–1969	19.23	24.00*	16.78*	27.61*
1970–1979	30.14	29.56*	25.51*	30.05*
1980 and later	45.30	38.22*	54.28*	32.57*
Sex				
Male	70.30	69.33	63.53*	56.60*
Female	29.70	30.67	36.47*	43.40*
Race/ethnicity				
White, non-Hispanic	68.00	62.00*	67.29*	61.73*
Black, non-Hispanic	12.68	18.89*	16.61*	17.75*
Other	19.32	19.11*	16.10*	20.52*
Service branch				
Army	33.99	47.56*	42.64*	48.21*
Navy and Coast Guard	22.81	14.00*	16.44*	18.24*
Marine Corps	11.57	11.33*	9.25*	7.41*
Air Force	31.63	27.11*	31.68*	26.14*
Military rank				
E1–E4	58.63	52.67	67.12*	50.00*
E5–E9, W0–W5	26.03	31.56	23.80*	33.39*
O1–O4	13.30	13.56	7.53*	12.95*
O5–O9	2.04	2.22	1.54*	3.66*
Occupational codes				
Combat specialists	18.71	16.44*	13.53*	13.52*
Electronic equipment repair	10.33	12.00*	10.10	11.32*
Communications/intelligence	9.48	11.78*	10.27*	7.90*
Health care	9.88	10.22	11.30	15.23*
Other technical & allied specialists	3.21	2.22	4.79*	2.93*
Functional support and admin	16.71	18.67*	19.01*	20.36*
Electrical/mechanical equip. repair	16.92	10.89*	17.81	14.01*
Craft workers	2.72	2.67*	2.23	2.69*
Service and supply	8.36	11.11*	9.25*	10.26*
Students, trainees, and other	3.68	4.00*	1.71*	1.79*
Smoking status				

Never	55.80	58.22	53.08	58.39*
Past	22.53	21.78	23.12	24.51*
Current	21.67	20.00	23.80	17.10*
Body mass index				
Underweight or normal weight	44.76	35.11*	43.66	32.33*
Overweight	46.54	51.33*	44.86	53.42*
Obese	8.70	13.56*	11.47	14.25*
Weekly alcohol use <sup>b</sup>				
None	44.01	42.89	48.80	47.31*
Light	30.07	28.44	26.20	30.13*
Moderate	13.51	15.56	12.67	12.05*
Heavy	12.41	13.11	12.33	10.50*
Prior physical trauma <sup>c</sup>				
No	90.87	67.56*	73.29*	61.56*
Yes	9.13	32.44*	26.71*	38.44*
Depression <sup>d</sup>				
No	95.48	93.78	95.21	93.97*
Yes	4.52	6.22	4.79	6.03*
Physical component summary score <sup>e</sup>				
Lowest 15%	15.07	24.22*	28.25*	28.58*
Middle 70%	70.51	67.33*	64.38*	63.93*
Highest 15%	14.42	8.44*	7.36*	7.49*

\*P<0.05 (significantly associated with respective tendinopathy by using chi-squared tests).

<sup>a</sup>Deployed up to 6 months prior to baseline survey assessment.

<sup>b</sup>For women: light = 1–3 drinks/week, moderate = 4–6 drinks/week, heavy = 7+ drinks/week. For men: light = 1–6 drinks/week, moderate = 7–13 drinks/week, heavy = 14+ drinks/week.

<sup>c</sup>Tendinopathy or fracture diagnosis prior to baseline survey assessment.

<sup>d</sup>Assessed using the Patient Health Questionnaire-9.

<sup>e</sup>Assessed using the Medical Outcomes Study Short Form 36-Item Survey for Veterans.

**Table 2.** Adjusted odd ratios (AORs) of developing Achilles tendinitis, patellar tendinitis, and plantar fasciitis among 80,106 active-duty personnel (2001–2008)

Baseline characteristics	Achilles tendinitis N=450		Patellar tendinitis N=584		Plantar fasciitis N=1228	
	AOR	95% CI	AOR	95% CI	AOR	95% CI
Deployment <sup>a</sup>						
No	1.00		1.00		1.00	
Yes	0.96	(0.68, 1.34)	0.98	(0.74, 1.28)	1.27	(1.04, 1.56)
Birth year						
Pre-1960	1.00		1.00		1.00	
1960–1969	0.80	(0.53, 1.21)	1.63	(0.94, 2.81)	0.94	(0.74, 1.19)
1970–1979	0.67	(0.43, 1.04)	1.69	(0.95, 2.98)	0.66	(0.51, 0.86)
1980 and later	0.62	(0.38, 1.00)	2.51	(1.40, 4.51)	0.49	(0.37, 0.66)
Sex						
Male	1.00		1.00		1.00	
Female	0.96	(0.76, 1.21)	1.02	(0.84, 1.24)	1.85	(1.62, 2.12)
Race/ethnicity						
White, non-Hispanic	1.00		1.00		1.00	
Black, non-Hispanic	1.35	(1.04, 1.75)	1.15	(0.90, 1.45)	1.02	(0.86, 1.20)
Other	0.94	(0.73, 1.22)	0.86	(0.68, 1.09)	0.93	(0.80, 1.09)
Service branch						
Army	1.00		1.00		1.00	
Navy and Coast Guard	0.53	(0.40, 0.71)	0.67	(0.52, 0.85)	0.67	(0.57, 0.78)
Marine Corps	0.85	(0.62, 1.18)	0.64	(0.47, 0.88)	0.71	(0.56, 0.89)
Air Force	0.76	(0.59, 0.96)	0.89	(0.73, 1.09)	0.69	(0.59, 0.80)
Military rank						
E1–E4	1.00		1.00		1.00	
E5–E9, W0–W5	1.02	(0.75, 1.38)	1.00	(0.76, 1.33)	0.99	(0.82, 1.20)
O1–O4	1.05	(0.74, 1.48)	0.79	(0.55, 1.13)	1.00	(0.82, 1.24)
O5–O9	0.74	(0.35, 1.59)	1.45	(0.64, 3.30)	1.26	(0.84, 1.88)
Occupational codes						
Combat specialists	1.00		1.00		1.00	
Electronic equipment repair	1.40	(0.98, 2.00)	1.31	(0.93, 1.84)	1.56	(1.24, 1.97)
Communications/intelligence	1.41	(0.98, 2.02)	1.26	(0.90, 1.78)	1.05	(0.81, 1.36)
Health care	1.10	(0.75, 1.62)	1.37	(0.97, 1.92)	1.55	(1.24, 1.94)
Other technical & allied spec.	0.77	(0.39, 1.50)	1.76	(1.13, 2.74)	1.17	(0.81, 1.70)
Functional support/admin	1.15	(0.83, 1.60)	1.35	(1.00, 1.84)	1.30	(1.06, 1.61)
Electrical/mech. equip. repair	0.80	(0.55, 1.16)	1.31	(0.97, 1.92)	1.26	(1.01, 1.58)
Craft workers	1.21	(0.65, 2.26)	1.01	(0.56, 1.83)	1.48	(1.01, 2.18)
Service and supply	1.35	(0.93, 1.94)	1.24	(0.87, 1.76)	1.36	(1.07, 1.73)
Students, trainees, and other	1.46	(0.86, 2.47)	0.66	(0.34, 1.28)	0.83	(0.53, 1.31)
Smoking status						
Never	1.00		1.00		1.00	
Past	0.88	(0.69, 1.12)	1.06	(0.86, 1.30)	0.98	(0.85, 1.13)

Current	0.88	(0.68, 1.14)	1.07	(0.86, 1.32)	0.81	(0.68, 0.95)
Body mass index						
Under or normal weight	1.00		1.00		1.00	
Overweight	1.29	(1.04, 1.59)	1.03	(0.86, 1.23)	1.62	(1.42, 1.86)
Obese	1.59	(1.16, 2.17)	1.19	(0.90, 1.57)	1.95	(1.61, 2.36)
Weekly alcohol use <sup>b</sup>						
None	1.00		1.00		1.00	
Light	1.04	(0.83, 1.31)	0.89	(0.72, 1.09)	1.08	(0.94, 1.24)
Moderate	1.33	(1.00, 1.76)	0.93	(0.71, 1.21)	1.00	(0.83, 1.20)
Heavy	1.27	(0.93, 1.72)	0.91	(0.69, 1.19)	1.02	(0.84, 1.25)
Prior physical trauma <sup>c</sup>						
No	1.00		1.00		1.00	
Yes	3.87	(3.16, 4.75)	2.92	(2.41, 3.53)	4.79	(4.24, 5.41)
Depression <sup>d</sup>						
No	1.00		1.00		1.00	
Yes	1.22	(0.82, 1.82)	0.80	(0.55, 1.19)	1.13	(0.88, 1.45)
Phys. comp. summary score <sup>e</sup>						
Lowest 15%	1.25	(0.99, 1.57)	1.72	(1.42, 2.09)	1.43	(1.25, 1.64)
Middle 70%	1.00		1.00		1.00	
Highest 15%	0.69	(0.49, 0.97)	0.60	(0.44, 0.83)	0.69	(0.55, 0.85)

<sup>a</sup>Deployed up to 6 months prior to baseline survey assessment.

<sup>b</sup>For women: light = 1–3 drinks/week, moderate = 4–6 drinks/week, heavy = 7+ drinks/week. For men: light = 1–6 drinks/week, moderate = 7–13 drinks/week, heavy = 14+ drinks/week.

<sup>c</sup>Tendinopathy or fracture diagnosis prior to baseline survey assessment.

<sup>d</sup>Assessed using the Patient Health Questionnaire-9.

<sup>e</sup>Physical component summary score, assessed using the Medical Outcomes Study Short Form 36-Item Survey for Veterans.

CI, confidence interval.

## REPORT DOCUMENTATION PAGE

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14. ABSTRACT  To prospectively identify risk factors for the development of lower extremity tendinopathy in U.S. military personnel, we utilized baseline data from the Millennium Cohort Study. Service members were enrolled in the Cohort in 2001, 2004, and 2007. We followed 80,106 active-duty subjects for the development of patellar tendonitis, Achilles tendonitis, and plantar fasciitis over 1 year as assessed by review of Department of Defense medical records. Regression analyses were used to estimate significant associations between tendinopathy outcomes and demographic, behavioral, and occupational characteristics. Medical record queries identified 443,575, and 1214 cases of Achilles tendinitis, patellar tendinitis, and plantar fasciitis, respectively. Recent deployment was associated with an increased risk for developing plantar fasciitis (adjusted odds ratio [AOR] = 1.27, 95% confidence interval [CI] = 1.04, 1.56). Moderate weekly alcohol use was associated with an increased risk for Achilles tendinitis (AOR = 1.35, 95% CI 1.02, 1.78). Overweight or obese individuals were more likely to develop both Achilles tendinitis and plantar fasciitis. Specific occupations, including health care workers, were at significantly higher risk for developing plantar fasciitis. Lower extremity tendinopathies are common among military service members, and this study identified several modifiable risk factors for their occurrence. These potential risk factors should be the focus of future preventive and intervention studies.					
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